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Review on Malaysia's national energy developments: Key policies, agencies, programmes and international involvements

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ABSTRACT

This paper aims to present a review on Malaysia's national energy developments by looking at various angles in terms of renewable energy and energy efficiency. Energy demand and consumption by sectors are presented as well as the fuel mix in electricity generation. Key energy policies implemented from the incorporation of Malaysia's national oil company, Petronas in 1974 until the National Green Technology Policy 2009 and a future policy will be addressed. The roles of key players as well as important agencies in energy development are briefly presented. Key programmes in energy development such as Malaysian Industrial Energy Efficiency Improvement Project, Small Renewable Energy Power Programme and Building Energy Efficiency Programme are discussed as well as successful initiatives from the programmes. Malaysia's international involvements towards reduction of greenhouse gas emissions and carbon emissions especially Montreal Protocol and Kyoto Protocol are highlighted. As a conclusion, Malaysia is aware of its role in formulating its national energy development policies, sensitive towards the country's development towards the environment and utilization of energy resources as well as conscientious and responsive towards the call for sustainable development in promoting renewable energy and energy efficiency.

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1. Introduction

Malaysia is a country in Southern Asia, separated into two regions by the South China Sea, with Peninsular Malaysia bordering Thailand and Singapore while East Malaysia bordering Indonesia and Brunei. It has a total area of 329,847 km^2 with an estimated population of 26 million as of 2009 [1]. Malaysia is gifted with natural resources in areas such as agriculture, forestry and minerals. Malaysia is one of the top exporters of natural rubber and palm oil in agriculture sector. Tin was once a major contributor to Malaysia's economy until the collapse of the tin market in early 1980s. Since then, petroleum and natural gas took over from tin as stronghold contributor to the economy. In 2004, Malaysia is ranked 24th in terms of world oil reserves and 13th for natural gas. 56% of the oil reserves exist in Peninsular Malaysia while 19% exist in East Malaysia. As of 1 January 2007, Petronas (Malaysia's national oil company) reported that oil and gas reserves in Malaysia amounted to 20.18 billion barrels equivalent. The government estimates that at the current production rates, Malaysia will be able to produce oil up to 18 years and gas for 35 years [2]. Thus, if new oil fields were not found, Malaysia would have its oil depleted around 2030 and affecting the energy sectors like industrial and transport. Section 2 presents Malaysia's supply and demand scenario from 2000 to 2010 as well as its energy mixed. Section 3 discusses the leading policies implemented by Malaysian government, while Section 4 presents main government agencies or key players in charge of the implementation of energy policies and Section 5 shows various key programmes implemented for energy development in Malaysia. Section 6 touches on a few important involvements of Malaysia in the international arena towards environmental protection and lastly conclusions.

2. Energy demand and consumption

Industrial sector in Malaysia accounts for 48.1% of the total GDP or USD 63.4 billion, followed by service sector (43.6%) and agriculture sector (8.3%) [3]. Table 1 shows the nominal GDP sector composition as of 2005, comparing Malaysia with a few key countries. Most developed countries like US and UK have high GDP in service sector. Developing countries like Malaysia and China for instance, have high GDP in industrial sector.

From the World Factbook of the Central Intelligence Agency (CIA) [1], electricity production in Malaysia stands at 103.2 billion kWh and consumption at 99.25 billion kWh, estimated in 2007. According to the final commercial energy demand by sector from the Ninth Malaysia Plan (9MP), 2006–2010, the largest energy consumer in Malaysia is transport sector (40.5%) in year 2005. This is followed by industrial sector (38.6%), residential and commercial sector (13.1%), non-energy sector (7.3%) and lastly agriculture and forestry sector (0.5%) as tabulated in Table 2. It is expected that the overall energy demand will increase at a rate of 6.3% per annum between 2005 and 2010 during the 9MP, a slight increase of 0.7% compare to during the 8MP. Transport and industrial sectors will continue to be the major energy consumers (41.1% and 38.8%, respectively) of the total energy demand by 2010.

The total supply of commercial energy in Malaysia increases from 2003 petajoules (PJ) in 2000 to 2526 PJ in 2005 and is projected to reach 3127.7 PJ in 2010 as shown in Table 3. The main sources of energy supply (fuel mix) were crude oil and petroleum products (46.8%), natural gas (41.3%), coal and coke (9.1%) and hydro (2.8%) in 2005. By 2010, in consistent with the Fuel Diversification Policy, crude oil and petroleum products will decrease to 44.7% while other energy sources will increase. The scenario is same for electricity generation, where electricity generation by oil is projected to reduce to 0.2% by 2010 while the dependence on coal increases to 36.5%. Total electricity generation is expected to drastically increase (almost double) from 69,280 GWh to 137,909 GWh by 2010 as shown in Table 4.

From Tables 2–4, we can observe increase energy demand (1243.7–2217.9 PJ) and supply (2003.1–3127.7 PJ) from 2000 to 2010. This is followed by increased electricity generation (69,280–137,909 GWh). Therefore, tremendous efforts must be made to ensure sustainable development such as efficient energy usage, reduction of energy wastage among the key energy sectors as well as encouraging the utilization of renewable energy as alternative source. Discussion of energy mix in Malaysia has been presented in

Table 1
Nominal GDP sector composition, January 2005.

Country	GDP	Composition in million dollars		
		Agriculture	Industrial	Service
World	46,660,000 (100%)	1,866,400 (4%)	14,931,200 (32%)	29,862,400 (64%)
United States	13,220,000 (100%)	118,980 (0.9%)	2,696,880 (20.4%)	10,390,920 (78.6%)
Japan	4,911,000 (100%)	78,576 (1.6%)	1,242,483 (25.3%)	3,589,941 (73.1%)
China	2,512,000 (100%)	298,928 (11.9%)	1,208,272 (48.1%)	1,004,800 (40%)
United Kingdom	2,341,000 (100%)	23,410 (1%)	599,296 (25.6%)	1,718,294 (73.4%)
India	796,100 (100%)	158,424 (19.9%)	153,647 (19.3%)	483,233 (60.7%)
Malaysia	131,800 (100%)	10,939 (8.3%)	63,396 (48.1%)	57,465 (43.6%)
Singapore	121,500 (100%)	0 (0%)	41,067 (33.8%)	80,433 (66.2%)

Table 2
Final commercial energy demand by sector, Malaysia, 2000–2010.

Source	Petajoules			Average annual growth rate	
	2000	2005	2010	8MP	9MP
Industrial[a]	477.6 (38.4%)	630.7 (38.6%)	859.9 (38.8%)	5.7%	6.4%
Transport	505.5 (40.6%)	661.3 (40.5%)	911.7 (41.1%)	5.5%	6.6%
Residential and commercial	162.0 (13.0%)	213.0 (13.1%)	284.9 (12.8%)	5.6%	6.0%
Non-energy[b]	94.2 (7.6%)	118.7 (7.3%)	144.7 (6.5%)	4.7%	4.0%
Agriculture and forestry	4.4 (0.4%)	8.0 (0.5%)	16.7 (0.8%)	12.9%	15.9%
Total	1243.7 (100%)	1613.7 (100%)	2217.9 (100%)	5.6%	6.3%

Source: 9MP (2006–2010), Table 19-2.
[a] Includes manufacturing, construction and mining.
[b] Includes natural gas, bitumen, asphalt, lubricants, industrial feedstock and grease.

Table 3
Primary commercial energy supply by source, Malaysia, 2000–2010.

Source	Petajoules			Average annual growth rate	
	2000	2005	2010	8MP	9MP
Crude oil and petroleum products[a]	988.1 (49.3%)	1181.2 (46.8%)	1400.0 (44.7%)	3.6%	3.5%
Natural gas[b]	845.6 (42.2%)	1043.9 (41.3%)	1300.0 (41.6%)	4.3%	4.5%
Coal and coke	104.1 (5.2%)	230.0 (9.1%)	350.0 (11.2%)	17.2%	8.8%
Hydro	65.3 (3.3%)	71.0 (2.8%)	77.7 (2.5%)	1.7%	1.8%
Total	2003.1 (100%)	2526.1 (100%)	3127.7 (100%)	4.7%	4.4%

Source: 9MP (2006–2010), Table 19-3.
[a] Refers to supply of commercial energy that has not undergone a transformation process to produce energy.
[b] Excludes flared gas, reinjected gas and exports of liquefied natural gas.

Table 4
Fuel mix in total electricity generation, Malaysia, 2000–2010.

Source	2000	2005	2010
Oil	4.2%	2.2%	0.2%
Coal	8.8%	21.8%	36.5%
Gas	77.0%	70.2%	55.9%
Hydro	10.0%	5.5%	5.6%
Other	0.0%	0.3%	1.8%
Total (GWh)	69,280 (100%)	94,299 (100%)	137,909 (100%)

Source: 9MP (2006–2010), Table 19-5.

length by many literatures such as [4–6] and is beyond the scope of this paper.

3. Energy development policies

Malaysia's development is tied to three key national policy frameworks: New Economic Policy (NEP), 1971–1990; National Development Policy (NDP), 1991–2000; and National Vision Policy (NVP), 2001–2010. The framework for providing energy development is mainly tied to National Energy Policy 1979, National Depletion Policy 1980 and Fuel Diversification Policy (Four Fuel Diversification Policy 1981 and Renewable Energy as the Fifth Fuel Policy 2000). The Four Fuel Diversification Policy 1981 identified the country's energy mix as oil, natural gas, coal and hydro power. Due to increasing oil price and environmental degradation, in 2001, the government of Malaysia introduced the Fifth Fuel Policy, adding renewable resources into the energy mix with important concerns placed on sustainability and efficiency. Since then, the government of Malaysia started placing emphasis on energy efficiency (EE) in industrial and commercial sectors as well as residential in domestic sectors, the utilization of renewable energy (RE) by promoting new RE resources such as biofuel, landfill gas, mini-hydro, solar, etc. and sustainable development of all energy resources. Table 5 shows the history of developments of various energy policies/acts in Malaysia's national energy development.

To further show the government's committee to promote low-carbon technology and ensure sustainable development while

Table 5
Malaysia's policy/act on national energy development.

Policy/act	Key emphasis
National Petroleum Policy (1975)	Introduced to ensure optimal use of petroleum resources and regulation of ownership, management and operation, and economic, social, and environmental safeguards in the exploitation of petroleum due to fast growing petroleum industry in Malaysia
National Energy Policy (1979)	Formulated with broad guidelines on long-term energy objectives and strategies to ensure efficient, secure and environmentally sustainable supplies of energy. Three main objectives: 1. Supply objective: To ensure the provision of adequate, secure, and cost-effective energy supplies through developing indigenous energy resources both non-renewable and renewable energy resources using the least cost options and diversification of supply sources both from within and outside the country 2. Utilization objective: To promote the efficient utilization of energy and to discourage wasteful and non-productive patterns of energy consumption 3. Environment objective: To minimize the negative impacts of energy production, transportation, conversion, utilization and consumption on the environment
National Depletion Policy (1980)	Introduced to safeguard against over exploitation of oil and gas reserves. Thus, it is production control policy
Four Fuel Diversification Policy (1981)	Fuel diversification was designed to avoid over-dependence on oil as main energy supply and aimed at placing increased emphasis on gas, hydro and coal in the energy mix
Electricity Supply Act (1990)	Regulates the licensing of electricity generation, transmission and distribution
Gas Supply Act (1993)	Regulates the licensing of the supply of gas to consumers through pipelines, prices, the control of gas supply pipelines, installations and appliances as well as safety
Fifth Fuel Policy (2000)	Introduced in recognition of the potential of biomass, biogas, municipal waste, solar and mini hydro as potential renewable energy resources for electricity generation
Energy Commission Act (2001)	The Energy Commission (or Suruhanjaya Tenaga) [14] was established to provide technical and performance regulation for the electricity and piped gas supply industries, as the safety regulator for electricity and piped gas and to advise the government on matters relating to electricity and piped gas supply including energy efficiency and renewable energy issues. The Electricity Supply Act 1990 and Gas Supply Act 1993 have both been amended to allow the Energy Commission to take over these responsibilities
National Biofuel Policy (2006)	Supports the five fuels diversification policy. Aimed at reducing the country's dependence on depleting fossil fuels, promoting the demand for palm oil. Five key thrusts: transport, industry, technologies, export and cleaner environment. Highlights: 1. Producing a biodiesel fuel blend of 5% processed palm oil with 95% petroleum diesel 2. Encouraging the use of biofuel by giving incentives for providing biodiesel pumps at fueling stations 3. Establishing industry standard for biodiesel quality under Standards and Industrial Research Institute of Malaysia (SIRIM) 4. Setting up of a palm oil biodiesel plant

Table 6
Significant progress and major improvements in the NGTP by sectors.

Sector	Progress and major improvements
Energy	
Energy supply	Application of green technology in power generation and in the energy supply side management, including co-generation by the industrial and commercial sectors
Energy utilization	Application of green technology in all energy utilization sectors and in demand side management programmes
Buildings	Adoption of green technology in the construction, management, maintenance and demolition of buildings
Water and waste management	Adoption of green technology in the management and utilization of water resources, waste water treatment, solid waste and sanitary landfill
Transportation	Incorporation of green technology in the transportation infrastructure and vehicles, in particular, biofuels and public road transport

conserving natural environment and resources, Malaysian government launched the National Green Technology Policy (NGTP) on 24 July 2009 [7]. Green technology refers to the development and application of products, equipment and systems used to conserve natural environment and resources, which minimizes and reduces negative impact of human activities which satisfy the following criteria: (i) it minimizes degradation of the environment, (ii) it has a zero or low green house gas (GHG) emission, (iii) it is safe for use and promotes healthy and improved environment for all forms of life, (iv) it conserves the use of energy and natural resources, and (v) it promotes the use of renewable resources [8]. The NGTP has five strategic thrusts as follows: (i) strengthen the institutional frameworks, (ii) provide conducive environment for green technology development, (iii) intensify human capital development in green technology, (iv) intensify green technology research and innovations, and (v) promotion and public awareness. In NGTP, the aim is that progress and improvements be made in major sectors such as energy, buildings, water and waste management and transportation towards fulfilling its goals as shown in Table 6. More information on NGTP may be obtained from the Ministry of Energy, Green Technology and Water's (KeTTHA) [8] or Malaysia Energy Centre [9].

The prime minister of Malaysia, Datuk Seri Najib Razak in his keynote speech [10] on 24 July 2009 during the launching of NGTP had stated that between 2009 and 2030, the global primary energy consumption is expected to rise by 1.6% annually and Malaysia's electricity demand is forecast to reach 18,947 MW in 2020 and 23,092 MW in 2030 which is 35% increment from 14,007 MW in 2008. Currently, Malaysia electricity capacity through RE stands at 50 MW and it is expected to reach about 2000 MW by 2020. Knowing this imminent scenario, Malaysian government will be instituting a RE law in the coming 2011 including a policy focusing on feed-in tariff (FiT) mechanism. Different forms of RE such as solar, biomass, biogas, wind, solid waste and sewage gas, geothermal and mini-hydro are given their share in the FiT mechanism as tabulated in Table 7 [11]. The proposed duration for the FiT ranges from 16 to 21 years with an annual digression up to 6%. A lesser focus seems to be given to mini-hydro and a heavier one to solar energy. The policy trends since petroleum was discovered towards promotion of RE has shown that Malaysia is aware of the importance of RE and EE in its energy development. Base on the energy trends, the national economic developments are also aligned in the Malaysia Plan (MP). Table 8 shows the key emphasis in energy developments from the 7MP to 10MP.

4. Key players in energy development

Malaysian government establishes energy policy to address issues of energy production, distribution, and consumption. The Department of Electricity and Gas Supply acts as the regulator while other players in the energy sector include energy supply and service companies, research and development institutions and consumers. Petroliam Nasional Berhad and Tenaga Nasional Berhad are the major players in Malaysia's energy sector.

4.1. Petroliam Nasional Berhad

Petroliam Nasional Berhad (Petronas) [12] was incorporated on 17 August 1974 under the Companies Act 1965. It is wholly owned by Malaysian government and is vested with the entire ownership and control of petroleum resources in Malaysia through the Petroleum Development Act 1974. It is Malaysia's national oil company responsible for exploration, development, refining, and marketing and distribution of petroleum products.

4.2. Tenaga Nasional Berhad

Tenaga Nasional Berhad (TNB) [13] is national electricity company in Peninsular Malaysia. It is a corporate entity established in 1990 and vested with electricity generation, transmission and distribution activities in Peninsular Malaysia. In the East Malaysia, Sabah Electricity Board (SEB) and Sarawak Electricity Supply Corporation (SESCO) are the electricity utilities. Apart from these three main utilities, electricity supply is also complimented by various independent power producers (IPPs), dedicated power producers and co-generators. The current total installed generation capacity in Peninsular Malaysia is 17,623 MW with TNB holding 8417 MW (47.8%), IPPs holding 6787 MW (38.5%) and another 2419 MW (13.7%) jointly owned by TNB and Malakoff (via Kapar Energy Ventures).

Three government agencies and one non-government organization (NGO) are actively involved in formulation of policies:

Table 7
Proposed FiT rate.

RE	Duration (year)	Tariff (RM/kWh)/(USD/kWh)	Annual degression	Displaced electricity cost (RM/kWh)
Wind	21	0.23–0.35/0.071–0.108	1%	0.22
Solar PV	21	1.25–1.75/0.386–0.541	6%	0.35
Solid waste and sewage gas	21	0.3–0.46/0.093–0.142	1.5%	0.22
Biomass	16	0.24–0.35/0.074–0.108	0.2%	0.22
Biogas	16	0.28–0.35/0.087–0.108	0.2%	0.22
Geothermal	21	0.28–0.46/0.087–0.142	1%	0.22
Mini-hydro	21	0.23–0.24/0.071–0.074	0%	0.22

Table 8
Malaysia's key emphasis from 7MP to 10MP for energy development.

Malaysia plan	Key emphasis
Seventh Malaysia Plan (1996–2000)	Emphasis on the sustainable development of depletable resources and the diversification of energy sources Ensuring adequacy of generating capacity as well as expanding and upgrading the transmission and distribution infrastructure Encouraged the use of new and alternative energy sources as well as efficient utilization of energy
Eighth Malaysia Plan (2001–2005)	Emphasis on the sustainable development of energy resources, both depletable and renewable. The energy mix includes five fuels: oil, gas, coal, hydro and RE Intensify efforts on ensuring adequacy, quality and security of energy supply Greater emphasis on EE: encourage efficient utilization of gas and RE as well as provide adequate electricity generating capacity Supports the development of industries in production of energy-related products and services Highlights in promoting RE and EE: Incentives for EE. Incentives for the use of RE resources. Incentives to maintain quality of power supply
Ninth Malaysia Plan (2006–2010)	Emphasis on strengthening initiatives for EE especially in transport, commercial and industrial sectors, and in government buildings Encourage better utilization of RE through diversify fuel sources Intensify efforts to further reduce the dependency on petroleum provides for more efforts to integrate alternative fuels Incentives in promoting RE and EE are further enhanced
Tenth Malaysia Plan (2011–2015)	Short term goals vested in NGTP: Increased public awareness and commitment for the adoption and application of green technology through advocacy programmes Widespread availability and recognition of green technology in terms of products, appliances, equipment and systems in the local market through standards, rating and labeling programmes Increased foreign and domestic direct investments (FDIs and DDIs) in green technology manufacturing and services sector Expansion of local research institutes and institutions of higher learning to expand research, development and innovation activities on green technology towards commercialization through appropriate mechanisms New RE act and FiT mechanism to be launched

Energy Commission, Ministry of Energy, Green Technology and Water, Malaysia Energy Centre and Centre for Environment, Technology and Development Malaysia.

4.3. Malaysia Energy Commission

Malaysia Energy Commission (EC) [14] was created pursuant to the Malaysian Energy Commission Act 2001 as a new regulator for the energy industry in Malaysia. This law was passed to fulfill the need to regulate an increasingly energy industry. In January 2002, EC was also empowered to regulate, enforce and promote all matters related to electricity and gas supply industry within the scope of the legislation provided by Electricity Supply Act 1990, Gas Supply Act 1993, Electricity Supply Regulations 1994, Gas Supply Regulations 1997 and Licensee Supply Regulations 1990. These functions were previously undertaken by the former Department of Electricity and Gas Supply.

4.4. Ministry of Energy, Green Technology and Water

Ministry of Energy, Green Technology & Water or Kementarian Tenaga, Teknologi Hijau dan Air (KeTTHA) [8] was established on 9 April 2009 following Malaysia's new cabinet line-up and restructuring, replacing Ministry of Energy, Water & Communications (MEWC) (since 2004). Prior to MEWC, its predecessor were Ministry of Energy, Communications & Multimedia (MECM) (since 1998) and Ministry of Energy, Telecommunication & Post (MTP) (since 1978). KeTTHA's role is to administer and manage the nation's energy, green technology and water functions

4.5. Malaysia Energy Centre

Malaysia Energy Centre or Pusat Tenaga Malaysia (PTM) [9] was established by the Malaysian Government in 1997 for the development and coordination of energy research. PTMs aim is to be the focal point and catalyst for linkages with universities, research institutions, industry, and national and international energy organizations. PTM offers membership to individuals and companies across the entire spectrum of Malaysian energy industry including electricity power industry, oil and gas industry, research institutions, institutions of higher learning, service providers, suppliers and energy consumers. Its four major functions are: (i) energy policy research, (ii) guardian and repository of the national energy database, (iii) promoter of national EE and RE programmes, and (iv) coordinator and lead manager in energy research and development, and demonstration projects.

4.6. Centre for Environment, Technology and Development Malaysia

Founded in 1985, Centre for Environment, Technology and Development Malaysia (CETDEM) [15] is an independent, non-profit, training, research, consultancy, referral, and development organization. It is committed to improving environmental quality through the appropriate use of technology and sustainable development. To date, CETDEM remains the only independent Malaysian NGO that actively addresses diverse environmental issues such as: (i) the impacts of long-term climate change on Malaysian society, (ii) sustainable energy, (iii) sustainable transport, (iv) organic farming (sustainable agriculture), and (v) sustainable development.

5. Key programmes in energy development

To cover all energy related developments is beyond the scope of this writing. This section describes five key programmes implemented in energy development towards EE and the promotion of utilization of RE. Each programme covers a broad spectrum of areas

and it is difficult to address all angles. Hence, only main objective and key outputs are presented.

5.1. Malaysian Industrial Energy Efficiency Improvement Project (MIEEIP)

The government of Malaysia initiated a project called Malaysian Industrial Energy Efficiency Improvement Project (MIEEIP) [16,17] in 1999 and ended in 2009 to improve EE in Malaysia's industrial sector. It achieved EE by removing barriers to efficient industry energy use and creating institutional capacity in policy development, planning, research and implementation of sustainable energy projects. The project's primary objective was to develop and implement activities that will build stakeholders' capacity and facilitate improved industrial EE which focuses on eight energy consuming industrial sub-sectors—food, wood, ceramic, cement, glass, rubber, pulp and paper, and iron and steel. Table 9 shows the potential energy and cost savings identified from factories audited in Malaysia under MIEEIP in year 2004. This was based on the findings from 48 factories representing different sub-sectors and further classified into three main categories: no cost measures, low cost measures and high cost measures as follows: (i) no cost measures—easy to implement, mostly deal with measurement and control as well as maintenance. Two classes are thermal and electric measures such as combustion and steam blow-down control, improvement of electric supply and distribution network, (ii) low cost measures—applied to thermal and electrical utilities as well as process improvements such as replacement of burner, heat recovery system, efficient air conditioning and compressed air systems. These require low investment and proven technologies to be implemented, and (iii) high cost measures—large investments and innovative technologies are involved. Two classes are incorporation of new technologies into existing plant such as co-generation and process modifications and new processes installation. As we can observe, from the findings, an energy saving between 1.6% and 35% of the annual energy consumption could be achieved across individual sector. The factories audited consumed approximately 39 PJ annually (which was 9% of total final energy consumed by manufacturing sector in 2004). Hence, implementation of all measures by the factories will reduce energy consumption by 5.6% and fuel demand will drop by 26.7% with potentially more than 1.5 million tonnes per year of avoided CO_2 emissions. In achieving its objective, the project further embodied eight key programmes as follows: (i) Energy-use Benchmarking, (ii) Energy Audit, (iii) Energy Rating, (iv) Energy Efficiency Promotion, (v) Energy Service Company (ESCO) Support, (vi) Energy Technology Demonstration, (vi) Local Energy Efficient Equipment Manufacturing Support, and (viii) Financial Institutional Participation. Among the success stories from implementing the eight key programmes included: (i) Publishing of Energy Efficiency and Conservation Guidelines Part 1: electrical energy-use equipment which covered industrial equipment such as transformers, motors, chillers, cooling towers, fans and blowers, pumps, air compressors, and lighting, (ii) energy audits were conducted for 48 factories from 11 energy intensive sectors and findings showed that approximately 934 ktonnes of energy a year (or about 9.4% of the final commercial energy demanded) by the eight targeted industries were consumed. Recommendations were put forth to be implemented by each factory where electricity usage and fuel demand will be reduced by 7% (or potential saving of 2.58 GJ of energy yearly), (iii) a sub-workgroup on motors was set up to promote high efficiency motors and the adoption of the European Committee of Manufactures of EU Electrical Machinery and Power Electronics scheme as the basis for the Malaysian standard for motors which could bring about potential savings of 72,000 GWh for the period between 2003 and 2004. Consequently,

Table 9
Potential energy and cost saving identified from the factories audited under MIEEIP, Malaysia, 2004.

Sector	Food	Wood	Ceramic	Cement	Glass	Rubber	Pulp and paper	Iron and steel	Total
Annual energy consumption (GJ/year)	1,835,430	1,031,528	774,061	21,556,595	4,000,370	611,307	5,080,208	4,223,247	39,112,746
Annual energy costs (Th. RM/year)	42,233	13,512	24,061	204,149	97,830	16,908	84,201	160,131	643,026
No cost energy savings (GJ/year)	24,361	7996	38,566	1375	31,499	57,010	51,559	64,194	276,510
Low cost energy saving (GJ/year)	111,087	131,702	75,229	6866	13,732	21,171	69,100	56,985	485,872
High cost energy savings (GJ/year)	238,139	220,863	41,561	337,266	58,913	84,292	690,889	148,874	1,820,796
Total energy savings (GJ/year)	373,587 (20.4%)	360,561 (35.0%)	155,35 (20.1%)	345,508 (1.6%)	104,095 (2.6%)	162,472 (26.6%)	811,547 (16.0%)	270,053 (6.4%)	2,583,178 (16.6%)
Total cost saving (Th. RM/year)	8515	5201	5992	33,752	2485	4313	19,767	5247	85,272
CO_2 emission reduction potential (tons/year)	27,988	30,378	14,463	444,667	8,069	18,931	194,403	22,836	761,734

Source: PTM. Findings of the energy audits.

on 4 December 2003, eight companies from the electric motor manufacturing supply and import industries signed a voluntary agreement to phase out inefficient motors by the year 2008, (iv) adoption of the internationally recognised energy performance contracting (EPC) approach that would offer a more viable solution to the industries, especially in a financial market that has not included EE as a potential portfolio, (v) the master energy services agreement (MESA) was drawn up by the MIEEIP team at PTM as a sample document to assist energy service companies and industries in the implementation of energy efficiency (EE) activities, (vi) an EE project loan financing scheme of RM 16 mil (USD 4.9 mil) had been setup at the Malaysian Industrial Development Finance Bhd (MIDF).

5.2. Small Renewable Energy Power Programme (SREPP)

Small Renewable Energy Power Programme (SREPP) was launched in 2001 with the aim of encouraging private sectors to undertake small power generation projects using renewable resources including biomass, biogas, municipal waste, solar, mini-hydro, and wind energy. EC was the technical secretariat for SREPP. Under SREPP, small power generation plants which utilize RE could apply to sell electricity to the national utility. The RE electricity producers were given a licence of 21 years effective from the date of commissioning of the power plant. Maximum power capacity delivered for a small RE plant to the grid was set to 10 MW. Successful SREPP projects include: (i) Jana Landfill at Puchong, Malaysia using biogas with 2 MW installed capacity which was the first grid connected RE project in Malaysia and (ii) TSH Bio-Energy Project at Kunak, Sabah using biomass (i.e. oil palm residues) with 14 MW installed capacity which had been estimated to mitigate 50 ktonnes of CO_2 equivalent. SREPP was targeted to contribute 5% (600 MW) of the country's electricity demand by 2005 but despite various efforts, only two plants (i.e. the Jana Landfill that delivered 2 MW and TSH Bio-Energy Project which delivered 10 MW to the grid) with combined 12 MW total capacity to the grid have been commissioned by 2005. By July 2004, MEWC reported that 60 projects under SREPP were approved with biomass (49%) and mini-hydro (43%) accounting for more than 90% of the total number of projects. Table 10 shows the approved projects under SREPP. Out of the 60 projects, seven projects have signed the RE Power Purchase Agreement (REPPA) which is an agreement between utility and project developers that covers the price of electricity, hours of connection to the grid and the penalty for non-compliance. Three types of financial incentives are established: pioneer status (PS), investment tax allowance (ITA) and import duty and sales tax exemption (ID-STE) to encourage the development of RE. These incentives are first provided under the 8 MP and National Budget 2001 when the government started to stress on the development of RE. Knowing that RE has grown tremendous since 2001, the government again enhances the incentives under National Budget 2009. A quick summary of the enhanced incentives are as follows: (i) the PS provides exemption from income tax on 100% of statutory income for 10 years, (ii) under the ITA, 100% of qualifying capital expenditure incurred within a period of 5 years can be utilized against 100% of the statutory income for each year of assessment, (iii) companies generating RE can apply for ID-STE on imported machinery, equipment, materials, spare parts and consumables used directly in the generation process and that are not produced locally. For locally purchased machinery, equipment, materials, spare parts and consumables, full exemption is given on sales tax. The details on incentives for RE and EE in 2009 can further be obtained from [18]. Recently, as of July 2009, another 31.5 MW had been generated and connected to the grid under SREPP (i.e. Kina Biopower: 10 MW, Seguntur Energy: 10 MW, Recycle Energy: 5.5 MW, Esajadi Power: 2 MW, AMDB Berhad: 4 MW).

One notable RE project which was launched in 2002 following SREPP is the Biomass Power Generation and Cogeneration in Palm Oil Industry (BioGen) project [16]. BioGen was developed to support government's RE efforts to curb the growth of greenhouse gas (GHG) emissions from fossil fuel fired combustion processes and unutilized biomass waste. It aimed to make use of unutilized biomass waste through the planting up of power generating capacity by using cogeneration technology. The development objectives: (i) to reduce GHG emissions, (ii) to reduce unused waste residue from palm oil, (iii) to promote growth of power generation and cogeneration, and (iv) to reduce barriers that have hindered the adoption of biomass power generation and cogeneration technologies. In 2006, two demonstration projects under BioGen as its full scale model were selected; (i) MHES Asia Biomass Power Plant in Bahau, Negeri Sembilan with total 13 MW capacity which cost RM 79mil (USD 24.5mil), and (ii) Felda Palm Industries Biogas Project with a capacity of 0.5 MW which cost RM 8mil (USD 2.5mil) at the same location. By 2009, these projects delivered 10 MW and 0.5 MW to the grid, respectively.

5.3. Malaysia Building Integrated Photovoltaic Technology Application (MBIPV) Project

On 25 July 2005, MBIPV project was launched by PTM and administered by the MEGTW. It will end in 31 December 2010. The principal objective of MBIPV project [16,19] is to reduce long-term cost of Building Integrated Photovoltaic Technology Application (BIPV) technology within Malaysian market, which subsequently lead to sustainable and widespread BIPV technology applications that avoid GHG emissions from the country's electricity sector. The project aims to catalyze BIPV technology acceptance among the public, policy makers, financiers and building industry, which lead towards a sustainable BIPV market beyond the completion of the project. The project specifically focuses on the market development for BIPV technology, and building the national capacities on three major areas: (i) policy and education, (ii) technical skill and market implementation, and (iii) technology development support. During MBIPV's 5-year duration, three main programs are implemented: (i) showcase, (ii) demonstration and (iii) SURIA 1000 and SURIA for

Table 10
Projects approved under the SREPP.

Types	Sources	Approved	Capacity (MW)	Capacity connected to grid (MW)
Biomass	Palm waste	22	200.5	165.9
	Wood waste	1	6.6	6.6
	Rice husk	2	12.0	12.0
	Municipal solid waste	1	5.0	5.0
	Mix	3	19.2	19.2
Landfill gas	–	5	10.2	10.0
Mini-hydro	–	26	99.2	97.4
Wind and solar	–	0	0	0
Total	–	60	352.7	316.1

developers programs, which feature investment in varying amounts to encourage investment in BIPV projects as well as accelerate the development of the local PV market. Buildings build using BIPV will have all BIPV panels integrated into the building design which to provide some electricity the building uses. The building will consume low energy as it combines EE measure and RE generation system. The BIPV system is also connected to the national electricity grid, helping to ease the power demand. The anchor program of MBIPV is the SURIA programme which are carried out via a bidding process in which the bidding is awarded to those who requested for the least financial support from the government. From the first five calls of SURIA 1000 programme, data showed that: (i) a total of 612 kWp in PV capacity is achieved (target is 450 kWp), (ii) the bidders' willingness to pay increases from 46.7% in the first call to 59.9% in the fifth call of total PV system price, and (iii) the PV system pricing (per kWp) shows fluctuating prices, from first call around RM 28k (USD 8.7k) to around RM 24k (USD 7.4k) in the fifth call. The SURIA 1000 is applicable for residential and commercial bidders. On the other hand, the SURIA for Developers programme is opened for property developers in Malaysia to develop housing development project which incorporates BIPV. Three housing developers who succeeded are: (i) SP Setia at location Setia Eco. Park in Shah Alam, Selangor developing PV systems in 20 of the 39 bungalows for around RM 1.58mil (USD 490k). The 5 kWp system cost over RM 170k (USD 52.5k) each and is expected to generate RM 150 (USD 46) worth of electricity every month, (ii) Putrajaya Perdana at location Precinct 16 of Putrajaya offering PV modules in 15 bungalows ranging from RM 2.9mil to RM 4mil (USD 896k to USD 1.24mil). The PV systems average around 5.4 kWp each, and (iii) Amarin Wickham at U-Thant area of Kuala Lumpur which incorporates PV cells into the sunshade on the roof of its low-density condominium. All three developments benefitted from a 30% to 35% subsidy under MBIPV project [20]. Other successful initiatives during the MBIPV project included: (i) setting up of a PV monitoring centre at Universiti Teknologi MARA (UiTM), (ii) launching of PV business development program (PBDP), (iii) implemented approved service provider (APVSP) scheme, (iv) started quality assurance scheme (QAS), (v) organized national PV conferences, and (vi) created PV awareness such as essay and drawing competitions among school children under the Ministry of Education.

The MIEEIP, BioGen and MBIPV were all assisted and supported by the United Nations Development Programme (UNDP), co-funded by Global Environment Facility (GEF), the Government of Malaysia and private sector. MIEEIP received financial aid of about USD 20.8mil, MBIPV about USD 23.2mil while BioGen about USD 14.7mil. Further information regarding these projects may be found from the UNDP in Malaysia website [16].

5.4. Building Energy Efficiency Programme (BEEP)

In Building Energy Efficiency Programme (BEEP), EE in buildings promotes optimal use of energy in heating, cooling and lighting which can be achieved by several strategies that optimize and regulate energy use in the building envelope such as windows with glazing to prevent heat gain, and controls for regulating energy use. It is a continual programme in which PTM services the energy audit of EE buildings and as technical advisory on EE of new premises, standard development and linkages with suppliers on new technologies. Two examples of EE buildings are low energy office and zero energy office.

1. Low energy office (LEO) building

   In 2004, MEWC (currently called KeTTHA) moved to its own building in the Federal Government Administrative Capital, Putrajaya. The building was designed to be a LEO building [21] and a showcase for EE. The design support was provided by the agency for Danish International Development Assistance (DanIDA) and local consultants. An ambitious goal of energy savings of more than 50% was set for EE of the building with an extra construction cost of less than 10%, giving a payback period for the extra investment of less than 10 years. To date, MEWC-LEO has achieved its building energy index close to 100 kWh/m^2/year and was declared winner of the ASEAN Energy Awards 2006, best practice in the new energy efficient building category.

2. Zero energy office (ZEO) project

   Following the success of LEO building, PTM building project officiated on July 2009 in Bandar Baru Bangi, Malaysia is a ZEO [9] initiative. ZEO requires that the building must not consume more electricity than can produce using RE sources on site. The intention was not only to make the PTM building a key demonstration building for EE in Malaysia with a designed energy index of 65 kWh/m^2/year compared to typical conventional office building in Kuala Lumpur of 250–300 kWh/m^2 year but also to provide a platform for advancing Malaysian construction industry towards adoption of ZEO standards within two decades. As shown in Fig. 1, BIPV systems with a total 92 kWp capacity were installed in various parts of the building. The BIPV panels integrated into the building design provided electricity for the building as well as feeding electricity to TNB grid which help shaves the peak power demand during the peak daylight hours. The system provides almost 50% of everyday electrical needs. It is the first of its kind in Malaysia and Southeast Asia that integrates EE and RE in one working building and cost RM 20mil (USD 6.2mil).

5.5. Green Building Index (GBI)

The GBI was launched in April 2009 is an initiated by Malaysian Institute of Architects and the Association of Consulting Engineers Malaysia, together with the building industry to enable green grading and certification of Malaysian buildings. GBI is a rating system providing comprehensive framework for building assessment in terms of EE, indoor environment quality, sustainable site planning and management, materials and resources, water efficiency, and innovation which is similar to the Green Star and Green Mark initiatives in Australia and Singapore, respectively. PTM-ZEO is the first green rated building in Malaysia.



Fig. 1. PTM's zero energy office building.

6. Participations in international arena

Issues regarding GHG emissions and improper wastes management which threatens biological diversity and climate change have always been linked to energy related developments such as generation, distribution and management of energy resources. Malaysia has actively participated and involved in key conventions regarding environment and sustainable development, such as convention on biological diversity, basel convention on the control of transboundary movements of hazardous wastes and their disposal, Montreal Protocol on substances that deplete the ozone layer and Kyoto Protocol to the United Nations Framework Convention on Climate Change, to name a few. Montreal Protocol and Kyoto Protocol are two key involvements.

6.1. Montreal Protocol on substances that deplete the ozone layer

The objective of the protocol is to protect the ozone layer by controlling emissions of substances that depletes it. Malaysia's involvement with Montreal Protocol began as early as 1987 during the Conference of Plenipotentiaries on the Protocol on Chlorofluorocarbons (CFCs) at the Vienna Convention for the protection of the ozone layer, which was held in Montreal [22]. Malaysia ratified Vienna Convention and Montreal Protocol on 29 August 1989. Subsequently the Public Services Department, Malaysia set up an ozone protection section (OPS) under Department of Environment in January 1997. OPS serves as the national focal point and one-stop agency for coordinating, monitoring, and implementing all of the Montreal Protocol Ozone-Depleting Substances (ODS) phase-out activities. The government has formulated policies and strategies to restrict and limit the use of ODS as well as promotes the use of non-ODS substitutes and alternatives. Malaysia's success in implementing Montreal Protocol can be seen both in declining imports and consumption of CFCs, from 3442 metric tonnes in 1995 to 662 metric tonnes in 2005 as shown in Table 11.

6.2. Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCC)

The objective of UNFCC [23] is to achieve stabilization of GHG concentrations in the atmosphere at a low enough level to prevent dangerous anthropogenic interference with the climate system while Kyoto Protocol extend this objective to further reduce GHG emissions by enhancing the national programs of developed countries (the Annex I Party) aimed at this goal and by establishing percentage reduction targets for the developed countries. Each Annex I Party is to ensure its total emissions from GHG sources over the commitment period do not exceed its allowable level of emissions while non-Annex I Parties (developing countries) are not mandated but encouraged in the emission reductions. The allowance to emit GHGs is measured in terms of one metric tonne of carbon dioxide equivalent (t CO_2 equiv.). There are three mechanisms in Kyoto Protocol towards GHG emission reduction: emission trading under Article 17, joint implementation (JI) under Article 6 and clean development mechanism (CDM) under Article 12.

Table 11
Malaysia's importation and consumption of CFCs, 1995–2010.

Year	Actual imports (metric tonnes)	Under Montreal Protocol control (metric tonnes)	Permit allocation[a] for National CFC Phase-Out Plan Commitment (metric tonnes)
1995	3442		
1996	3048		
1997	3351		
1998	2351		
1999	2040	3271	
2000	1651	3271	
2001	1538	3271	
2002	1606	3271	1855
2003	1174	3271	1566
2004	1116	3271	1136
2005	662	1635	699
2006		1635	579
2007		491	490
2008		491	401
2009		491	332
2010		0	0

Source: Ozone Protection Section, Department of Environment Malaysia, 2003.
[a] Approved permits for importation.

Malaysia is a non-Annex I Party to the UNFCC. It became a signatory to Kyoto Protocol on 12 March 1999 and ratified Kyoto Protocol on 4 September 2002. The Kyoto Protocol entered into force on 16 February 2005. As a non-Annex I Party, Malaysia can only engages in CDM projects with any Annex I Party for reduction of GHG emissions while gaining carbon credits through certified emission reductions (CER). PTM acts as the secretariat (energy) and reports to the technical committee (MEWC) in carrying out its responsibilities. It provides input for the formulation of CDM policy, conducts technical evaluation as well as creates a national database on major stakeholders. From the Malaysia Initial National Communication report submitted to UNFCC by Ministry of Science, Technology and the Environment on July 2000 [24], Malaysia's GHG emissions totaled to 144 million (t CO_2 equiv.) in 1994. The net emissions (after accounting for sinks), totaled to 76 million (t CO_2 equiv.). On a per capita basis, the net emissions equivalent to 3.7 tonnes. In terms of GHGs, carbon dioxide accounted for 67.5%, methane 32.4% and nitrous oxide 0.1% of the total CO_2 equivalent emissions. Of these, fuel combustion (from energy sector) contributed the most with 86.7% of total CO_2 emissions. It is seen that Malaysia has a huge potential in terms of carbon trading by involving in the CDM projects. It was reported in [25] that the annual potential in Malaysia reached 18 million CERs in 2010, about 100 million (t CO_2 equiv.) between 2006 and 2012. With PTM estimating the price range to be USD 3–10 tonnes of CO_2 equiv., it represents a cash flow of USD 0.3–1 billion to Malaysia from carbon trading. Despite carbon trading being relatively new in Malaysia, Malaysia is the first country in the world to be awarded CERs by the United Nation Executive Board of CDM via a biomass project in Sabah in 2007. As at 1 March 2009, there were a total of 4660 future CDM projects registered, based on data released by the United Nations Environment Programme resource centre. Of this, Malaysia has 156 CDM projects in the pipeline or 3.3% of the list [26]. Further information on Malaysia's carbon trading potential can be found in [27]. More recently, the Prime Minister of Malaysia stated that Malaysia is committed to do its best in combating climate change. As such, Malaysia will voluntarily slash by up to 40% her carbon emission by 2020 compared with 2005 levels [28].

7. Conclusions

Malaysia is a developing country and an important subscriber to reducing climate change and promoting sustainable environment. This can be seen from the government of Malaysia's steps in formulating the nation's energy policies since petroleum was found to adding RE in its energy mix as well as promoting EE. The energy policies are also aligned to the nation's economic development and from time to time encourage through its national budget and Malaysia Plan. Recently, the government of Malaysia launches the NGTP which encourages the development and application of products, equipment and systems used to conserve the natural environment and resources, which minimizes

and reduces negative impact of human activities through green technology. It is expected that a new RE act and a feed-in tariff mechanism will be launched in 2011 which will further boost RE and EE awareness. Various key players such as Petronas and TNB as well as EC, KeTTHA and PTM play importance roles in the energy developments. Implemented programmes such as MIEEIP, SREPP and BEEP further showed the government of Malaysia's efforts towards EE and utilization of RE. The energy developments have been positive due to the government's role in promotion through attractive incentives. On the other hand, in the international arena, Malaysia plays an important role as a key player who propagates the idea of emission reductions and environmental protection cause by energy-related activities by ratifying Montreal Protocol and Kyoto Protocol. As such, in overall we see that Malaysia is aware of its role in formulating national development policies, sensitive towards cause and effect in the country's development to the environment and utilization of energy resources, as well as conscientious and responsive towards the call for sustainable development not only domestically but also internationally.

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